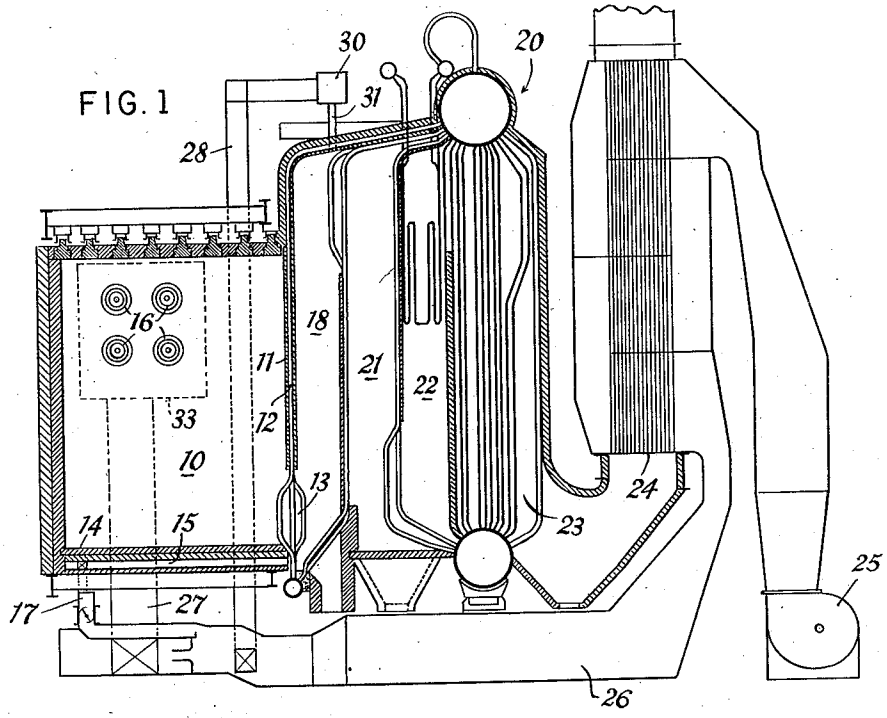
Nov. 5, 1957 C. E. ROGERS ET AL 2,812,212

LIQUID FUEL BURNER

Filed April 17, 1951

FIG. 1



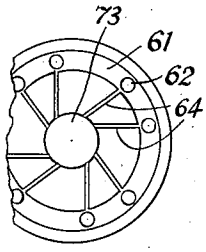


FIG. 6

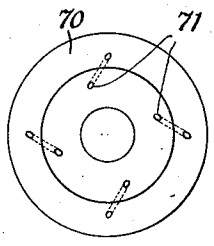


FIG. 7

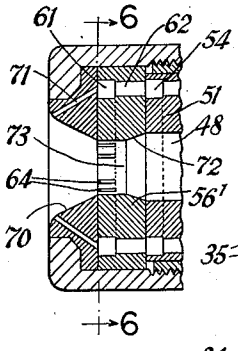


FIG. 5

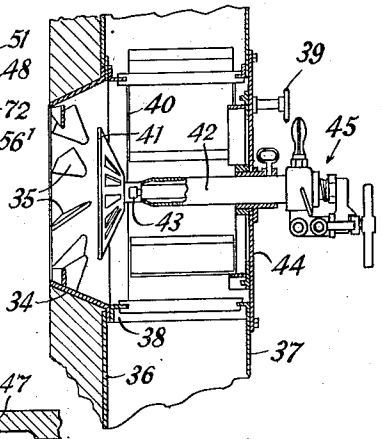


FIG. 2

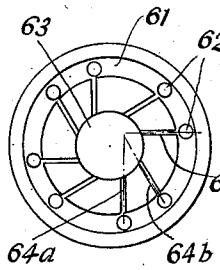


FIG. 4

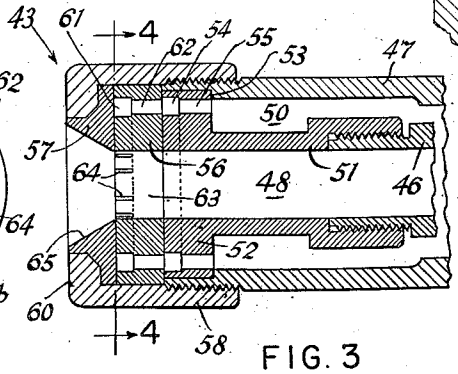


FIG. 3

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LIQUID FUEL BURNER

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4 Claims. (Cl. 299—114)

The present invention relates to liquid fuel burners, and more particularly to fluid atomizing fuel burners for erosive liquid fuels.

In the successful combustion of a liquid fuel it is desirable to atomize the fuel to a fine mist so that combustion air can be intimately mixed therewith to complete the combustion process. Some liquid fuels, such as the residual liquors resulting from a cellulosic pulping process, are so erosive, as to reduce the atomizing effect of one or more of the atomizer parts, necessitating frequent replacement of those parts. Residual liquors resulting from the sulphite cooking process are particularly erosive due to dissolved and suspended solid matter therein and also frequently contain fibrous material which tends to plug small diameter liquor flow passages in atomizer parts.

In accordance with the present invention we provide a liquid fuel burner assembly constructed and arranged to successfully atomize erosive liquids without excessive wear on the atomizer parts. This is accomplished by a novel arrangement of atomizing fluid flow passageways arranged to intersect a high velocity flowing stream of the liquid to be atomized. The atomizing effect is accomplished out of direct contact with the confining liquid flow passageway. In addition the liquid flow passageway is relatively unobstructed and not susceptible to pluggage due to the presence of fibrous materials in the liquid. The substitution of our burner atomizer assembly has resulted in a manifold increase in the life of burner parts when compared with the burners heretofore known. Moreover this increased life and avoidance of excess wear is accomplished while maintaining a degree of atomization at least comparable with the atomizing assemblies of the prior art.

The various features of novelty which characterize our invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, its operating advantages and specific objects attained by its use, reference should be had to the accompanying drawings and descriptive matter in which we have illustrated and described a preferred embodiment of our invention.

Of the drawings:

Fig. 1 is an elevational view, partly in section, of a vapor generation unit and furnace incorporating the burner of the present invention;

Fig. 2 is an enlarged section elevation of the liquid fuel burner;

Fig. 3 is a further enlarged longitudinal section of the atomizer assembly of the liquid fuel burner;

Fig. 4 is an end view of one element of the atomizer taken on the line 4—4 of Fig. 3;

Fig. 5 is a longitudinal section of a modified form of atomizer assembly;

Fig. 6 is an end view of an element of the atomizer taken on the line 6—6 of Fig. 5; and

Fig. 7 is an end view of the atomizer tip shown in Fig. 5.

In the illustrated embodiment of the invention the

burner is associated with a furnace 10 constructed and arranged for the combustion of a pulp residual liquor resulting from the digestion of cellulosic material in a relatively pure magnesium base cooking liquor. The residual liquor from this process is particularly erosive to burner atomizers and the usual type of steam atomizing burner has had a useful life measured in hours, and when constructed with expensive alloy parts a life not exceeding a few days at best. In this process the residual liquor is preferably burned in suspension and a high degree of spray atomization and thorough mixing with combustion air is highly desirable to complete the combustion process and to cause the conversion of the magnesium in the liquor to a reactive form of magnesium oxide.

Referring to Fig. 1 the furnace 10 is substantially completely lined with high alumina refractory materials. High combustion temperatures are attained in this furnace. As shown, the rear wall 11 of the furnace consists of refractory blocks supported upon fluid cooled tubes 12 with a gas outlet 13 in the rear wall positioned upwardly adjacent the furnace floor 14. The furnace floor is formed of hollow tile 15 covered with high aluminum refractories, with preheated air delivered to the front portion of the floor through a valved duct 17, passed through the hollow tiles and discharged into the upflow open pass 18 of an associated vapor generator 20.

Residual liquor at a concentration of 50 to 60% solids is delivered to the upper portion of the furnace 10 through burner ports 16 positioned in opposite side walls of the furnace. The residual liquor is atomized by the burners, as hereinafter described, mixed with air, and the combustible matter therein burned in suspension within the furnace 10. Leaving the furnace outlet 13 the combustion gases generated in the furnace are passed through a series of fluid cooled upright open gas passes 18, 21 and 22 and pass through the convection pass 23 of the vapor generator. Thereafter the gases pass through an air heater 24, and are treated in a supplementary system for the separation of the MgO solids in the gases and for the absorption of sulphur oxides in a wash liquid (not shown). As disclosed in U. S. Patent No. 2,354,175 the time-temperature relationship during the combustion of the residual liquor is quite important in attaining a reactive magnesium oxide solid residue.

Advantageously the combustion air used in the furnace 10 is preheated to assist in an efficient and rapid combustion of the organic matter in the residual liquor. Air from the forced draft fan 25 is passed through the air heater 24 into a duct 26 for distribution to the furnace 10 through the valved branch duct connections 17, 27 and 28. The duct connections 28 extend upwardly on opposite sides of the furnace to open into a horizontally disposed distributing manifold 30 which is provided with a series of discharge pipes 31 extending between the tubes forming the roof of the gas passes 18 and 21 and arranged to discharge into the gas stream passing into the gas pass 21. The duct connections 27 likewise extend from the duct 26 to an enclosed housing 33 surrounding the burner ports on the opposite sides of the furnace.

Each of the burner ports 16 is provided with an air register and a liquid fuel atomizer assembly, whereby the fuel and air are delivered to the furnace 10 through each port. A vertical elevation (taken along the centerline of a burner port and in a plane perpendicular to the side wall of the furnace) of an individual air register and atomizer assembly is shown in Fig. 2. A ring member 34 having an inwardly tapering surface, and provided with a circular series of air directing vanes 35, is fastened to the casing 36 enclosing the refractory furnace, so that the ring member projects into the burner port. The outer cover plate 37 of the air housing 33 is spaced from and generally parallel to the casing 36, and is connected there-

to by a circular series of brackets **38**. A circular series of curved air directing blades **40**, each mounted on an individual axis, are interconnected by linkage for simultaneous adjustment from a common exterior lever **39**. The blades can be closed to cut off air flow to the furnace, and can be adjustably opened to regulate the quantity of air passing therethrough. Thus in all open positions, the air stream passing between adjacent blades **40** is given a swirling motion.

In addition, a slotted diffusion cone **41** is positioned in the burner port **16** by the barrel **42** of the liquid fuel burner. The combination of the blades **40** and the diffusion cone **41** directs the flow of combustion air through the port in a whirling movement of the air mass surrounding and impinging upon a fine spray of liquor discharged from the atomizer tip **43** of the burner. In the embodiment of Fig. 2, the barrel **42** is formed of an elongated tubular member projecting through a cover plate **44** which is bolted to the plate **37**. The barrel is centered so as to be substantially coaxial with respect to the member **34**, and is exteriorly provided with the conventional coupling provisions for the separate admission of both liquid fuel and atomizing fluid, as indicated generally at **45**. The atomizing fluid may be steam, or other gaseous or vapor fluid.

The atomizing assembly of the burner tip **43** is shown in detail in Figs. 3 and 4, and includes an inner and an outer tube **46** and **47**, respectively. The tubes are coaxial and define separate passageways **48** and **50** for the liquid fuel and the atomizing fluid. In the arrangement shown, the passageway **48** conducts the liquid fuel while the passageway **50**, between the tubes **46** and **47**, is utilized for the flow of a fluid, such as steam, used to atomize the liquid in the burner tip. A sprayer head or nozzle **51** is threaded to the end portion of the tube **46** and is provided with a flanged end portion **52** circumferentially engaging an inner shoulder **53** formed in the end portion of the tube **47**. The nozzle **51** serves to center and to maintain the desired end spacing relationship between the tubes **46** and **47**. In the construction shown an open sided annular chamber **54** is machined in the face of the flanged end portion **52**, with a circumferential series of drilled ports **55** providing flow communication between the passabeway **50** and the chamber **54**.

An atomizing plate **56** and a tip member **57** are assembled in series abutting relationship to the nozzle **51**, and maintained in position by a cap member **58** which is threaded onto the outer end portion of the tube **47**. An inwardly extending flange **60** of the cap member **58** engages a correspondingly recessed outer portion of the tip **57** to maintain coaxial alignment of the assembly and to provide a substantially unobstructed flow path for the liquid fuel passing through the passageway **48**.

As shown in Figs. 3 and 4, the atomizing plate **56** is formed with an open sided annular chamber **61** on the face thereof, and a circumferential series of drilled openings **62** extend from the chamber through the body of the plate **56** in a direction parallel to the axis of the central bore or throat **63**.

A plurality of slotted passageways **64** are formed in one face of the plate **56**, extending from the chamber **61** inwardly to the confining wall of the throat **63**. While the centerline of each passageway lies in a plane parallel to the axis of the throat and the member **51**, the planes of the centerlines of individual passageways are not in parallelism. In the construction shown in the drawings the passageways **64** are elongated in a direction parallel to the axis of the throat and are milled in the plate **56** from the face thereof to a depth corresponding with the depth of the annular chamber **61**. Since the atomization effectiveness of the fluid passed through the passageways **64** to intersect the stream of liquid flowing through the throat **63** is greatly influenced by the velocity of the pressure fluid jets discharged from the passageways, the dimensions and number of jets will be selected to attain the desired results with a preferred flow rate of fluid. While in the embodiment shown, the passageways **64** are rectangular in cross-section for ease of fabrication, it will be understood the cross-sectional shape can be varied without adversely affecting the atomizing efficiency of the apparatus.

As shown in Fig. 4, the passageways **64** are arranged in pairs with the intersection of the centerlines of each pair occurring within the throat **63** at a position intermediate the circumference and the longitudinal axis of the throat. With the arrangement shown and described, the pairs of intersecting jets tend to establish a series of swirls in the liquid stream, with the number of swirls corresponding with the number of pairs of passageways provided in the plate **62**. In addition, the jets promote an effective spinning effect within the liquid stream so that on emerging from the throat the liquid is thoroughly atomized. The action of the jets on the liquid stream tends to compress the stream and to minimize the erosive contact of the swirling liquid upon the confining walls.

Each pair of passageways **64**, such as **64A** and **64B**, is arranged with the centerline of the passageway **64A** spaced from and parallel to a radial line intersecting the longitudinal axis of the throat **63**, while the centerline of the passageway **64B** intersects the centerline of passageway **64A** within the throat with an included angle of the order of 30° to 36°.

The tip **57** is provided with an outwardly flaring conical surface **65** diverging from the circumference of the throat **63** at an angle of approximately 25° to 30°. The tip member is subjected to some internal wear with the expansion of the atomized liquid stream in discharging from the atomizer.

In a modified form of the invention, as shown in Figs. 5, 6 and 7, the tip is provided with a series of fluid jets which tend to recompress the discharging atomized liquid stream and protect the inner surface of the tip member against erosion.

Referring to Figs. 5 and 7, the tip member **70** is provided with four equally spaced ports **71** opening at their inner ends to the chamber **61** of the adjoining plate **56'** and extending through the body of the tip to discharge into the atomized liquid stream discharging through the throat **73** of the atomizer. The ports **71** converge, with their longitudinal axes lying along the surface of a right cone having a base angle of 60°, and with the axis of each displaced 30° from a line drawn from the apex of the cone to the base and passing through one end of the port. The jet impulse of the fluid passing through the ports **71** and impinging on the atomized liquid stream discharging through the throat **73** is directed in the same direction as the swirl imposed by the fluid jets discharging through the passageways **64**.

It is sometimes of advantage to restrict the cross-sectional area of the throat in the atomizing plate, particularly when the burner is normally operated at a liquid flow capacity less than the maximum. Such a restriction is shown in the modified construction of plate **56'** shown in Fig. 5, where the throat **73** is provided with conically tapered inlet end portion **72**, and a cylindrical mixing portion **74** of smaller diameter than the passageway **48**. Otherwise the plate **56'** is provided with the ports **62**, chamber **61** and passageways **64**, as in the plate **56** construction previously described.

By way of example and not of limitation, an atomizer of the type described had a capacity of approximately 3600 pounds per hour of sulphite liquor having a solids content of approximately 60%. The liquor was delivered to the burners at a pressure of 60 pounds per square inch gauge, and a temperature of 230 F. The throat **63** of the burner was $2\frac{7}{64}$ inches in diameter, and 8 passageways **64** were used, each of which was $\frac{1}{8}$" long and had a width of .016". Steam, at a pressure of 100 pounds per square inch gauge, was used as the atomizing fluid. Even though the sulphite liquor was highly erosive the burner

was used continuously for over two months without an appreciable reduction in the atomizing effectiveness of the atomizer. Other designs of burners had previously been used under identical operating conditions and comparable atomizing efficiencies, but the effective life of such burners had never exceeded a period of approximately two days.

While in accordance with the provisions of the statutes we have illustrated and described herein the best form and mode of operation of the invention now known to us, those skilled in the art will understand that changes may be made in the form of the apparatus disclosed without departing from the spirit of the invention covered by our claims, and that certain features of our invention may sometimes be used to advantage without a corresponding use of other features.

We claim:

1. As an article of manufacture, a sprayer plate comprising a disk having a central bore with merging frustoconical and cylindrical portions, means defining an annular groove in one face of said disk radially spaced from and surrounding the cylindrical portion of said central bore, a plurality of orifices extending from said groove to the other face of said disk, and a plurality of circumferentially spaced passageways extending inwardly from said groove to the cylindrical portion of said central bore, the passageways of each pair positioned with their centerlines intersecting at an acute angle within and at a diameter less than the diameter of the cylindrical portion of said central bore.

2. As an article of manufacture, a sprayer plate comprising a disk having a central bore, means defining an annular groove in one face of said disk radially spaced from said bore, a plurality of orifices extending from said groove to the other face of said disk, and a plurality of circumferentially spaced passageways extending inwardly from said groove to the central bore of said disk, alternate passageways positioned with their centerlines tangent to a circle of less diameter than the diameter of said central bore, the remaining passageways positioned with their centerlines tangent to a second circle of lesser diameter than said first mentioned circle.

3. A liquid fuel burner comprising walls defining coaxial passageways for liquid fuel and steam respectively, a sprayer plate operatively connected to said passageways and having a central bore forming a continuation of said liquid fuel passageway, an annular groove in one face of said sprayer plate radially spaced from and surrounding said bore and in communication with said steam passageway, a plurality of circumferentially spaced steam flow passageways leading from said annular groove to said bore, alternate passageways positioned with their centerlines tangent to a circle of less diameter than the diameter of said central bore, the remaining passageways positioned with their centerlines tangent to a second circle of lesser diameter than said first mentioned circle, and a discharge tip coaxially engaging said sprayer plate and having internal surfaces diverging outwardly from the bore of said sprayer plate.

4. A liquid fuel burner comprising walls defining coaxial passageways for liquid fuel and steam respectively, a sprayer plate operatively connected to said passageways and having a central bore forming a continuation of said liquid fuel passageway, an annular groove in one face of said sprayer plate radially spaced from and surrounding said bore and in communication with said steam passageway, a plurality of circumferentially spaced steam flow passageways leading from said annular groove to said bore, alternate passageways positioned with their centerlines tangent to a circle of less diameter than the diameter of said central bore, the remaining passageways positioned with their centerlines tangent to a second circle of lesser diameter than said first mentioned circle, a discharge tip coaxially engaging said sprayer plate and having internal surfaces diverging outwardly from the bore of said sprayer plate, and means forming a series of ports in said tip arranged to project converging jets of steam into the liquid fuel discharging through the diverging internal surfaces of said discharge tip.

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